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ABSTRACT

This teaching unit is designed to help students in grades 4-8 explore the concept of measurement in the context of the earth's atmosphere. The units in this series have been developed to enhance and enrich mathematics, science, and technology education and to accommodate different teaching and learning styles. Each unit consists of a story line presenting the context for the problems to be solved, lists of the mathematics and science concepts addressed, background notes for the teacher, a list of teacher resources, and an activity complete with blackline masters. Also included are suggestions for extensions to the problems and their relationship to national mathematics standards. The storyline for this unit is students learning how scientists use satellites, lasers, optical detectors, and wavelengths of light to measure the presence of certain gaseous elements, compounds, and aerosols in the earth's atmosphere. (MM)

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National Aeronautics and
Space Administration

Langley Research Center
Hampton, VA 23681-0001

ED 458 136

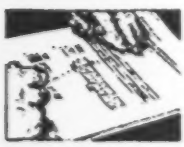
Program 2 in the 1999-2000 Series

The Measurement of All Things:

Atmospheric Detectives

- *make an aerosol sampler to analyze the aerosols in your community*

- *use computers to investigate satellite images and remote sensing*



- *graph, analyze, interpret, and present data*

Story line: Students will learn how scientists use satellites, lasers, optical detectors, and wavelengths of light to measure the presence of certain gaseous elements, compounds, and aerosols in the Earth's atmosphere.

Math Concepts: Computation and Estimation, Measurement, Patterns, Tools

Science Concepts: Scientific Method, Earth Patterns, Earth/Space Systems

NASA Research: LIDAR, SAGE II, PICASSO-CENA

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Educator's Guide	
Teachers & Students	Grades 4-8

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SE 053307

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PROGRAM SUMMARY

OBJECTIVES

In The Measurement of All Things: Atmospheric Detectives, students are introduced to the study of atmospheric science and the measurement of aerosols. They will investigate science, mathematics, and remote sensing techniques to show how the Sun's radiation and elements and compounds in the atmosphere react to each other. They will also investigate how human activity affects these resulting gases and particles in the atmosphere. Students will also learn about the tools and techniques NASA researchers use to measure the amount of particles or aerosols in the atmosphere. NASA researchers will show how data on aerosols is collected and how the results from the data are used in their work. To apply what they have learned about air-borne aerosols, students will work in groups to make an aerosol sampler, a simple adhesive tool that allows students to collect data and estimate the extent of aerosols present in their school community and neighborhoods. By participating in this activity, students will obtain a quantitative measurement of the aerosols present in the neighborhood of the school and at students' homes. This activity is taken from *Space-Based Astronomy, A Teacher's Guide with Activities*, a NASA publication for grades 5-8. For more information on *The Measurement of All Things: Atmospheric Detectives*, visit the following section of the NASA CONNECT web site: **http://edu.larc.nasa.gov/connect/detect.html**

While visiting the corresponding web page for this program, students can access "Atmospheric Detectives", the technology-based component of the program. This online activity is located in "Norbert's Lab" at **http://edu.larc.nasa.gov/connect/detect/norbert/lab.html** With this interactive activity, students will use the computer, like NASA scientists, to investigate remote sensing. Students will be challenged to interpret a mystery image on screen using what, where, and why questions to guide them. After interpreting the mystery image, students will be prepared to determine the density or concentration of aerosols over two different regions of the Earth. Students will use information like altitude, distance, and latitude and longitude to interpret the data.

Access to information is critical to making career decisions. *Career Corner* is located at **http://edu.larc.nasa.gov/connect/detect/ca2.html** and is a web-based component that highlights the professionals who appear in the program, *The Measurement of All Things: Atmospheric Detectives*. This web site includes pictures of the professionals; summarizes their duties and responsibilities; and includes details about the person, event, or situation that greatly influenced their career choice.

TEACHER BACKGROUND

AEROSOLS AND PARTICLES

Mathematics and remote measurements are used to study aerosols in the Earth's atmosphere. These aerosols are both naturally occurring and man-made. **Naturally occurring aerosols:** Sea salt, pollen, and volcanic ash; **Man-made aerosols:** Factory emissions, automobile exhaust, and smoke from biomass burning. Even on a clear day, many small aerosols are present in the atmosphere. Dust particles are tossed into the air by wind, and other aerosols are produced as combustion products from cars, fireplaces, industry, volcanic eruptions, and a variety of other sources, including meteorites and comets.

Every day about 100 tons of meteorite and comet dust falls to Earth from space! Overall, aerosols scatter some of the light that comes through the atmosphere from the Sun.

When dust, smoke, pollen, or tiny droplets of water float in the air, the sky becomes hazy. As a result of the haze or pollution, the atmospheric "thickness" is slightly increased, causing the Sun's energy to be reflected into space or absorbed in chemical reactions within the Earth's atmosphere.

Because haze scatters some sunlight back into space, many scientists think that increased haze over the Northern Hemisphere has caused a slight cooling effect. In some regions, haze can be so thick that shadows are faint or even invisible. Haze also obscures visibility.

GLOBAL WARMING AND MEASURING AEROSOLS

As a result of aerosols in the atmosphere, some of the Sun's energy is reflected into the atmosphere. The remainder of the Sun's energy reaches the surface of the Earth and increases surface temperature. The warm surface of the Earth emits infrared radiation back into space. Some of this infrared radiation is absorbed by "greenhouse gases" in the atmosphere, like water vapor, carbon dioxide, and methane, and re-emitted to the Earth. This process causes global warming and is referred to as "the greenhouse effect."

To understand how aerosols effect climate and global temperature, scientists measure the characteristics of aerosols. One effective method of measuring these characteristics is the use of a high-energy laser beam emitted from a platform in space. The **PICASSO-CENA** satellite, launching in 2003, will provide the platform for laser beam emission, **LIDAR** (Light Detection And Ranging). The LIDAR system will measure the backscattered light from aerosols and calculate their location in the atmosphere by using the time lapse between light emission and detection. This system will improve our understanding of how aerosols effect climate and global temperatures.

THE ACTIVITY: IT'S IN THE AIR

NATIONAL MATH STANDARDS

- Problem Solving
- Measurement
- Number Sense and Numeration
- Probability and Statistics
- Data Analysis

NATIONAL SCIENCE STANDARDS

- Science as Inquiry
- Earth and Space Science
- Science in Personal and Social Perspectives
- Science and Technology

NATIONAL TECHNOLOGY STANDARDS

- Basic Operations and Concepts
- Technology Research Tools

INSTRUCTIONAL OBJECTIVES

Students will

- work cooperatively in groups to collect, analyze, and interpret data, and make predictions.
- measure to nearest centimeter.
- quantitatively measure the aerosols present in their school and home communities.
- use random sampling to plot/determine points on a coordinate grid.
- calculate the mean for each of the 10 random samples.
- observe and record weather conditions.
- record, graph, and present the results.
- determine how weather conditions and geography affect the amount of aerosols in the atmosphere.
- understand how chemical hazards (pollutants in the air) affect our climate.
- demonstrate a sound understanding of the nature and operation of technology systems.
- use technology to locate, collect, and evaluate information.

TEACHER RESOURCES

Books

Clark, D. (1987). *The Cosmos From Space-Astronomical Breakthroughs - The View From Beyond Earth's Atmosphere.* New York, NY: Crown Publishers.

Forrester, Frank H. (1981). *1001 Questions Answered About the Weather.* New York, NY: Dover Publications, Inc..

Pethoud, R. (1990). *PI in the Sky: Hands-On Mathematical Activities for Teaching Astronomy.* Tucson, AZ: Zephyr Press.

Porcellino, M. (1991). *Young Astronomer's Guide to the Night Sky.* Blue Ridge Summit, PA: TAB Books.

Schaff, F. (1990). *Seeing the Sky: 100 Projects, Activities & Explorations in Astronomy.* New York, NY: John Wiley & Sons, Inc.

Williams, J. (1997). *The Weather Book.* New York, NY: Vintage Books, a division of Random House, Inc.

Pamphlets

NASA Facts: Atmospheric Aerosols: What are they and why are they so important? FS-1996-08-11-LaRC

Check out Norbert's Lab! ——▷

Web Sites

Studying the Earth's Environment from Space
http://see.gsfc.nasa.gov/edu/SEES
Exploring the Environment
http://www.cotf.edu/ete/main.html
Wings
http://wings.ucdavis.edu/Curriculums/Atmosphere/index.html
Earth and Sky
http://www.earthsky.com
PICASSO-CENA Outreach web site
http://www-arb.larc.nasa.gov/picasso-cena/outreach.html
Norbert's Lab on the NASA CONNECT web site
http://edu.larc.nasa.gov/connect/detect/norbert/lab.html

BEFORE THE ACTIVITY

Encourage students to research aerosols, the atmosphere, and other related topics by using the library, the Internet, and the resources above. Ask students to share their thoughts or write their responses to the following questions:

What is air?
What would happen to you if air did not surround the Earth?
Is the atmosphere always the same?
How do atmospheric changes affect our daily lives?

VOCABULARY

aerosols- particles of liquids or solids dispersed as a suspension in gas
atmosphere- the air surrounding the Earth - composed mainly of nitrogen and oxygen, with traces of carbon dioxide, water vapor, and other gases; air acts as a buffer between Earth and the Sun
carbon dioxide- a minor but very important component of the atmosphere; carbon dioxide traps infrared radiation
chlorofluorocarbons- a family of compounds of chlorine, fluorine, and carbon, entirely of industrial origin. CFC's include refrigerants and propellants for spray cans.
fluorocarbons- any of various inert organic compounds in which fluorine replaces hydrogen; used as aerosol propellants, refrigerants, solvents, and lubricants and in making plastics and resins
freon- a trademark for any of various nonflammable gaseous or liquid fluorocarbons that are used mainly as working fluids in refrigeration and air conditioning and as aerosol propellants
the **greenhouse effect**- a process by which significant changes in the chemistry of Earth's atmosphere may enhance the natural process that warms our planet and elevates temperatures
laser (light amplification by stimulated emission of radiation)- an active instrument that produces discretely coherent pulses of light (Light waves with no phase differences or with predictable phase differences are said to be coherent.)
the **metric system**- a decimal system of weights and measures based on the meter as a unit length and the kilogram as a unit mass
ozone - an almost colorless, gaseous form of oxygen with an odor similar to weak chlorine that is a relatively unstable compound of three atoms of oxygen
particulate matter- of, pertaining to, or formed of separate particles of matter
relative humidity- the ratio of the amount of water vapor in the air at a specific temperature to the maximum capacity of the air at that temperature
satellite- a free-flying object that orbits the Earth, another planet, or the Sun

Note: Due to wide variations in air quality, we recommend that this experiment be pretested in the school neighborhood to learn how long to expose the sampler. The time period may have to be extended to several days to show measurable results. Although the collector will probably collect aerosols of extraterrestrial origin, telling which aerosols are extraterrestrial will require analytical techniques beyond the scope of this lesson.

MATERIALS NEEDED FOR EACH GROUP

2 pieces clear contact paper (14 cm square)
2 copies of Aerosol Sampler Grid (page 12)
2 pieces cardboard or 1/4-inch plywood (30 cm square)
Cellophane tape
Magnifying glass
Dice
1 copy of Student Data Worksheet I (page 13)
1 copy of Aerosol Sampler Line Graph (page 15)

MATERIALS NEEDED FOR EACH STUDENT

1 piece clear contact paper (14 cm square)
1 copy of Aerosol Sampler Grid (page 12)
1 piece cardboard or 1/4-inch plywood (30 cm square)
1 copy of Student Data Worksheet II (page 14)

THE ACTIVITY

Note: This activity will require one day of preparation and two days for implementation.

1. Day 1: Prepare the particulate sampler

- Locate the specific location of a flat, elevated, open area. The surface does not have to be horizontal. Students need to have easy access to this area.
- Divide the class into 4 research groups.
- Have each group tape 1 piece of contact paper in the center of the cardboard with the sticky side up. Keep the protective backing on the contact paper *(see Figure 1)*.
- Repeat above procedures for a total of 2 aerosol samplers for each research group.

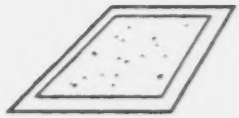


Figure 1. Sampler

2. Day 2: Conduct the experiment at school and analyze the results

- Assign each research group an area on the school grounds to place its aerosol sampler.
- Have each group complete the "Morning" column on Table A: Observations of Weather Conditions on Student Data Worksheet 1 *(page 13)*.

Note: You will need to read the local paper, watch the local weather, or visit **http://www.weather.com** before filling in statistics.

- Have each group select one of its samplers for use in the predetermined morning time. Place the aerosol sampler outside on a flat surface, preferably a meter or two above the ground.

Note: You may have to anchor the sampler if the air is windy. Make sure the contact paper is firmly taped to the cardboard.

- Remove the protective backing from the contact paper.
- Expose the sampler to the outside for at least 2 hours. Place the Aerosol Sampler Grid, grid side down, over the collecting surface and return the sampler to the classroom.
- Remove the sampler from the cardboard and observe the aerosols from the back side of the clear contact paper (grid should be showing through). *(see Figure 2.)*

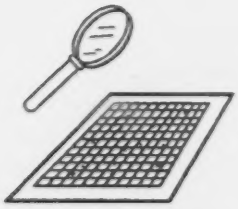


***Figure 2. Completed sampler** - The grid has been placed over the sticky side of the contact paper.*

- Using the magnifying glass or holding the contact paper up to a light (i.e., an overhead projector), count the number of aerosols found in each of 10 randomly selected squares on the Aerosol Sampler Grid. Randomly select the squares by tossing the dice twice. For example, if the numbers come up 2 and 5, the square is found in the second row, fifth column.
- Record the number of aerosols in each sample square in the "# aerosols (Morning)" column of Table B: Aerosol Sampler Collection Data on the Student Data Worksheet I *(page 13)*. Add up all the aerosols in the 10 randomly selected squares to get a total. Next, divide the total number of aerosols (counted by 10) to get an average or mean number per square. Each square is 2 centimeters per side.
- Repeat steps 3-8 for selected times for the afternoon sample. After the average number of aerosols for each of the 2 samplers has been calculated, construct a line graph using the Aerosol Sampler Line Graph *(page 15)* to compare the data.
- Compare and discuss the results of the 2 findings.

3. **Day 2 (continued): Conduct the experiment at home and analyze the results at school.**
   - Have students prepare their own aerosol samplers *(see Day 1, page 6)* to take home and place outside on a flat surface, preferably a meter or two above the ground.

> **Note:** As in the class activity, students may have to anchor the sampler if the air is windy. Remind students to make sure the contact paper is firmly taped to the cardboard.

   - Remove the protective backing from the contact paper.
   - Students should expose the sampler overnight (approx. 8 hours), place the Aerosol Sampler Grid, grid side down over the collecting surface and return the sampler to school.

4. **Day 3: Analyze the results at school.**
   - Repeat procedure from Day 2. Record data in Table C: Aerosol Sampler Data: Collection from Home on Student Data Worksheet II *(page 14)*.
   - Have students write their address and the total number of aerosols from Table C: Aerosol Sampler Data: Collection from Home on Student Data Worksheet II *(page 14)* on a self-adhesive note.
   - Divide a map or diagram of your community or area into 4 regions: Northwest, Northeast, Southwest, Southeast. Have students place their labeled adhesive notes on the map/diagram where they live.
   - Using the data from the map, find the average for each region (NW, NE, SW and SE) and make a class graph of the data. See Graph of Data Collected from Home *(page 16)*.

• Compare and discuss the results of the data.

> **Note:** Contact your local air pollution authority or the U.S. Environmental Protection Agency for additional information about the air quality in your community.

5. Analyzing the Data

Students should review their observations and data and respond to these questions in their journals or in the form of a classroom discussion:

1. Did the weather conditions affect the results of this activity? If so, how? *(See data collected on local weather conditions.)*

2. What types of weather conditions could cause the results to change? Why? *(Conditions like wind, rain, snow, or extreme heat could cause a change in results. These conditions affect the number of aerosols present in the air.)*

3. What other factors can be identified that could affect the results of the activity? *(Time left outside, location of sampler, and contaminated contact paper may affect the results of the activity.)*

4. What caused the different amounts of aerosol matter found in the atmospheric samples? *(Answers vary according to population, industry, agriculture and geography. For example, combustion products from cars, fireplaces, volcanic eruptions, and a variety of other sources including meteorites and comets, could contribute to the number of aerosols collected.)*

5. What are other methods you might use to collect data on atmospheric particulate matter? *(Observe deposits of aerosols on objects, i.e., cars, glass, furniture. See Extending the Activity for other possible answers.)*

6. Look at the map and the data you collected from home. What is the relationship between where a student lives and the number of aerosols collected? *(Answers vary according to population, industry, agriculture and geography. For example, combustion products from cars, fireplaces, volcanic eruptions, and a variety of other sources, including meteorites and comets, could contribute to the amount of aerosols collected in a community.)*

EXTENDING THE ACTIVITY

1. Using a very clean wet/dry vacuum, pour a measured amount of water into the bottom of the container. Allow the vacuum to run with the hose suspended in the air. After a predetermined period of time, turn the vacuum off and collect the water inside. Pour the water into clean beakers or other lab containers. The samples can be used for simple comparison activities, for study under a microscope, or for spectral analysis.

2. Make a transparency of the Aerosol Sampler Grid *(page 12)*. Collect an aerosol sample by using contact paper, as described in the activity, but instead of placing the contact paper on the paper grid, place it on the transparent grid. Show the resulting grid on the overhead projector.

3. For more extension activities, please visit "Norbert's Lab" on the NASA CONNECT web site at **http://edu.larc.nasa.gov/connect/detect/norbert/lab.html**

4. Using the data collected and recorded from the NASA CONNECT Student Activity, have students make comparisons, predictions, and inferences *(see the examples below)*.

Encourage students to visit all the rooms in Norbert's lab.

Example: The following data was collected by students at St. Stephens Indian School in Wyoming.

	Morning	Afternoon
Date	10-19-99	10-19-99
Time	9:00 a.m.	12:00 noon
Temperature	26° F	36° F
Weather Conditions (cloudy,r ainy, sunny)	clear	sunny /h azy
Relative Humidity	92%	82%
Wind Speed	3 mph	4 mph
Barometer	30.32"	30.32"
Dusto r other visible aerosols?	No	No

The following data was collected at the St. Stephens school playground.

	# Aerosols (Morning)	# Aerosols (Afternoon)
Sample Square 1	3	7
Sample Square 2	3	0
Sample Square 3	1	3
Sample Square 4	3	4
Sample Square 5	0	5
Sample Square 6	4	1
Sample Square 7	3	1
Sample Square 8	2	9
Sample Square 9	2	13
Sample Square 10	1	8
Total	22	51
AVERAGE number of aerosols per square	2.2	5.1

CUE CARDS, GRAPHS, GRIDS, TABLES

CUE CARDS

Dr. M. Patrick McCormick, Hampton University

How does the number of aerosols in the atmosphere affect the Earth's weather conditions?

_____

_____

_____

Dr. Russell DeYoung, NASA Langley Research Center

How do aerosols affect our health? _____

_____

What is remote sensing? _____

_____

Name and describe the two types of remote sensing and give examples of each.

_____

_____

_____

_____

How are aerosols in the atmosphere measured? _____

Explain how scientists use LIDAR to help them measure the aerosols in the atmosphere.

_____

_____

Dr. John Anderson & Dr. Ali Omar, Hampton University

Compare and contrast SAGE II with PICASSO-CENA. _____

_____

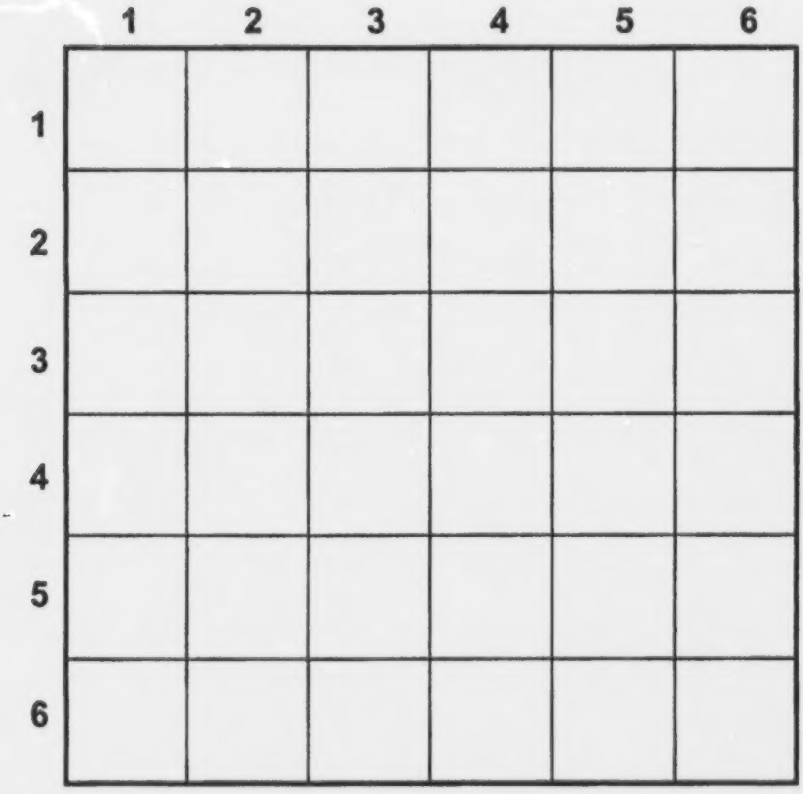
_____

How will PICASSO-CENA help scientists measure aerosols more accurately? _____

_____

_____

AEROSOL SAMPLER GRID



Each square is two centimeters per side.

STUDENT DATA WORKSHEET I

Table A. Observations of Weather Conditions

	Morning	Afternoon
Date		
Time		
Temperature		
Weather Conditions (cloudy, rainy,s unny)		
Relative Humidity		
Wind Speed		
Barometer		
Dust or other visible aerosols?		

Table B. Aerosol Sampler Collection Data

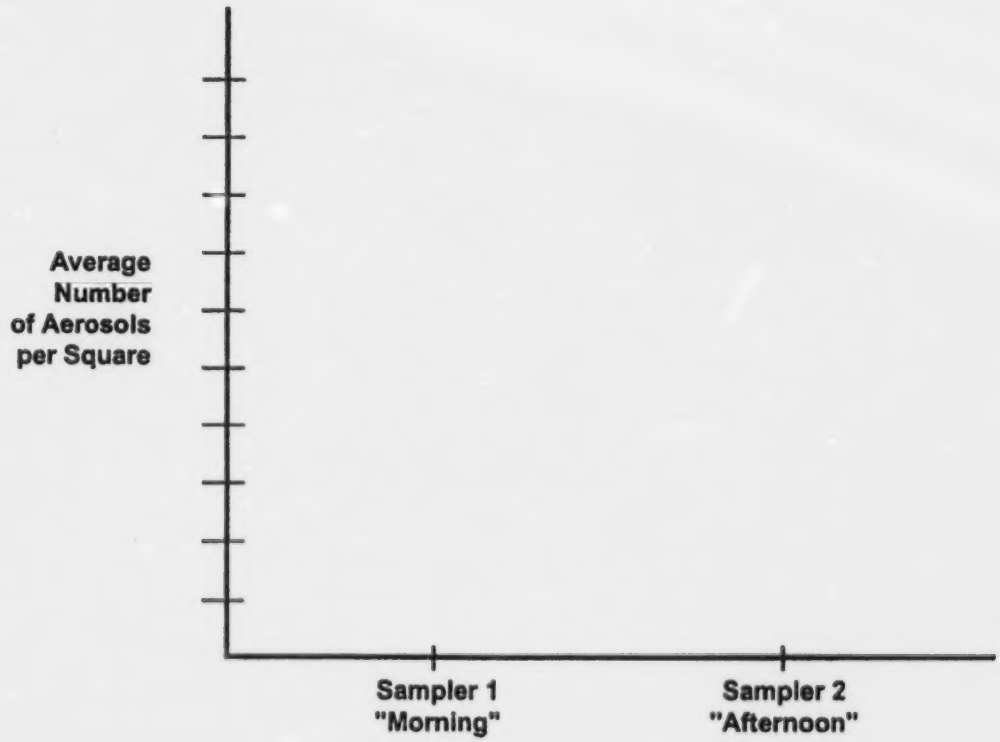
	# Aerosols (Morning)	# Aerosols (Afternoon)
Sample Square 1		
Sample Square 2		
Sample Square 3		
Sample Square 4		
Sample Square 5		
Sample Square 6		
Sample Square 7		
Sample Square 8		
Sample Square 9		
Sample Square 10		
Total		
AVERAGE number of aerosols per square		

STUDENT DATA WORKSHEET II

Table C. Aerosol Sampler Data: Collection from Home

	# Aerosols (Home)
Sample Square 1	
Sample Square 2	
Sample Square 3	
Sample Square 4	
Sample Square 5	
Sample Square 6	
Sample Square 7	
Sample Square 8	
Sample Square 9	
Sample Square 10	
Total	

AEROSOL SAMPLER LINE GRAPH



GRAPH OF DATA COLLECTED FROM HOME